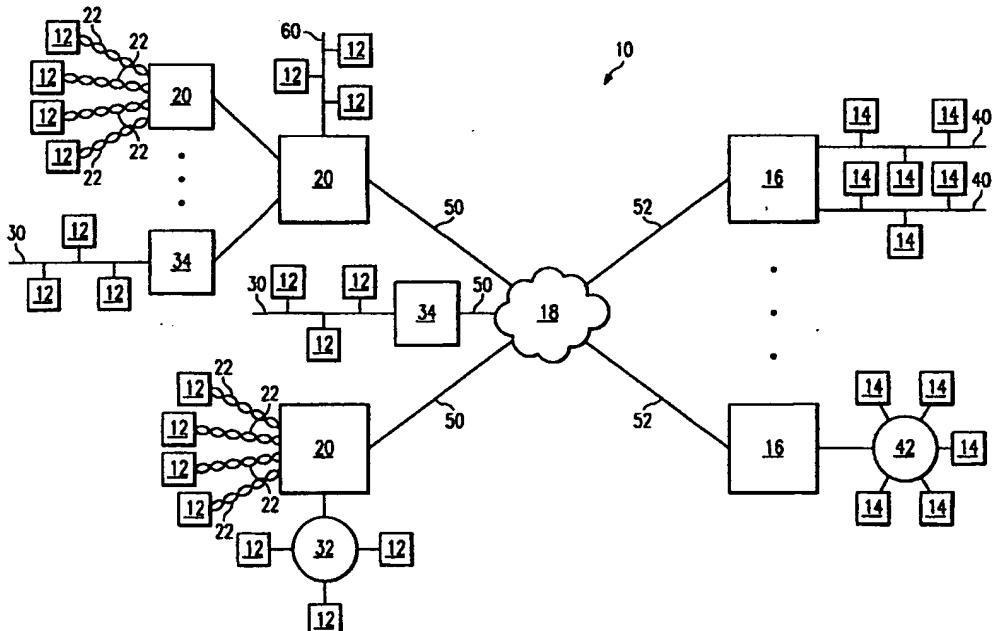




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(54) Title: ACCESS SERVER WITH SWITCHED ARCHITECTURE



(57) Abstract

A communication system includes an access server that communicates information between a wide area network (WAN) and a local area network (LAN). The access server includes a WAN interface, a switch fabric, a number of route processors, and a LAN interface. The switch fabric directs information from the WAN interface to a selected route processor based on its loading characteristics.

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## ACCESS SERVER WITH SWITCHED ARCHITECTURE

### TECHNICAL FIELD OF THE INVENTION

This invention relates in general to data communication, and more particularly to a switched architecture access server.

### 5 BACKGROUND OF THE INVENTION

A router provides communication between two different networks. For example, a router may allow communication between a wide area network (WAN) and a local area network (LAN). Depending on the particular application, routers perform a variety of termination, conversion, segmentation, reassembly, and addressing functions.

Existing routers are termination devices that terminate information communicated using a WAN protocol, such as asynchronous transfer mode (ATM). The router converts and routes the received information to a destination using a LAN protocol, such as Ethernet. The termination and subsequent routing of information is a processor-intensive activity that often degrades the quality of service or bandwidth available to network users. Continuing bandwidth demands from bursty traffic, the proliferation of high bandwidth applications like real-time video, and the overall increased use of data communication networks exacerbates this problem. Existing routers fail to provide modularity and scalability to accommodate these increased demands for fast and reliable data service.

SUMMARY OF THE INVENTION

In accordance with the present invention, the disadvantages and problems associated with routers have been substantially reduced or eliminated. In particular, 5 the present invention includes an access server with a switch fabric that directs information to a selected route processor based on its loading characteristics.

In accordance with one embodiment of the present invention, a communication system includes a communication server coupled to a communication device using a subscriber line that forms a local loop between the communication device and the communication server. An access server, coupled to the communication server using a data network, includes a switch fabric coupled to a number of route 10 processors. The switch fabric directs information from the communication device to a selected route processor based on 15 its loading characteristics.

In accordance with another embodiment of the present invention, an access server includes a first network interface to receive information associated with a session. The access server also includes a number of route 20 processors, each route processor having a loading characteristic indicating its level of activity. A switch fabric has a first port and a number of second ports. The first port of the switch fabric couples to the first network interface, and each second port of the switch fabric couples to an associated route processor. The switch fabric couples information associated with a session 25 to a selected route processor based on its loading characteristics.

Important technical advantages of the present invention include an access server that provides communication between a first network and a second network using a switch fabric and a number of route processors. In 30

a particular embodiment, the first network is a WAN that supports asynchronous transfer mode (ATM) communication and the second network is a LAN that supports Ethernet communication. The switch fabric routes, switches, and/or 5 directs information associated with data sessions to a number of route processors based on their loading characteristics. The loading characteristics may include a packet rate, error rate, session count, idle time, or other measure that indicates the level of activity of each 10 route processor.

Another important technical advantage of the present invention includes the establishment and efficient handling of information associated with sessions. The switch fabric identifies sessions, establishes mappings and virtual 15 channels, and switches information to selected route processors using high bandwidth techniques, such as ATM cell routing. A number of separate route processors perform processor-intensive LAN packet assembly, authentication, and routing depending on their current 20 loading characteristics. The access server can upgrade or add route processors in a modular and scalable fashion to accommodate more sessions and higher bandwidth use of the access server. The switch fabric, therefore, provides a load balancing, traffic segmentation, and session 25 management function not found in traditional routers.

Further technical advantages of the present invention include a LAN interface that provides a switching function to segment traffic communicated to devices serviced by the LAN. In addition, the LAN interface also directs traffic 30 received from devices serviced by the LAN to selected route processors. In a particular embodiment, the WAN interface, switch fabric, route processors, and LAN interface all reside in a single housing. Other important technical

advantages are readily apparent to one skilled in the art from the following figures, descriptions, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

5 For a more complete understanding of the present invention, and for further features and advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, in which:

10 FIGURE 1 illustrates a communication system 10 that includes an access server in accordance with the present invention;

FIGURE 2 illustrates in more detail the access server;

15 FIGURES 3A through 3C illustrate information maintained by the access server;

FIGURE 4 is a flow chart of a method of operation of the access server; and

20 FIGURE 5 illustrates signaling between different components in the communication system to establish a session using the access server.

DETAILED DESCRIPTION OF THE INVENTION

FIGURE 1 illustrates a communication system 10 that provides communication between communication devices 12 and 14. More particularly, communication system 10 includes an access server 16 that provides devices 14 access to data network 18.

25 Devices 12 couple to data network 18 using a number of different devices and techniques. In one embodiment, devices 12 couple to a communication server 20 in the local loop using traditional twisted pair subscriber lines 22. Devices 12 and communication server 20 exchange information using high bandwidth digital subscriber line technology, referred to generally as XDSL. Communication server 20 may reside at a central office, remote terminal, or other

access point in communication system 10 that allows coupling to local loops formed by twisted pair subscriber lines 22. U.S. Patent Application Serial No. 08/625,769 entitled "Communication Server Apparatus and Method" 5 discloses in detail the operation of devices 12 and communication server 20 in communication system 10, and is hereby incorporated by reference for all purposes.

Devices 12 may also be associated with a local area network (LAN), such as an Ethernet network 30, a token ring network 32, a fiber distributed data interface (FDDI) network, an asynchronous transfer mode (ATM) network 60, or any other association or arrangement of devices 12 in a network environment (referred to generally as LAN 30). LAN 10 30 supports Ethernet (10 Mbps), Fast Ethernet (100 Mbps), Gigabit Ethernet, switched Ethernet, or any other suitable networking protocol or technology. LAN 30 couples to data 15 network 18 using communication server 20, network interface 34, or any combination of communication server 20 and network interface 34. In one embodiment, network interface 20 34 comprises hubs, routers, bridges, gateways, and other suitable communication devices and related software that support suitable communication protocols to couple LAN 30 to data network 18.

Data network 18 supports communication between 25 communication server 20, network interface 34, and access server 16. In a particular embodiment, data network 18 is part of a wide area network (WAN) that supports a suitable communication technology, such as ATM, frame relay, X.25 30 packet switching, statistical multiplexers, switched multi-megabit data service (SMDS), high-level data link control (HDLC), serial line Internet protocol (SLIP), point-to-point protocol (PPP), transmission control protocol/Internet Protocol (TCP/IP) or other suitable WAN protocol or technology. Although the discussion below

focuses on a particular ATM embodiment of data network 18, communication system 10 contemplates any suitable WAN protocol or technology.

Devices 14, like devices 12, may be arranged in a LAN, such as an Ethernet network 40, a token ring network 42, an FDDI network, or other suitable network or arrangement of devices 14 (referred to generally as LAN 40). LAN 40 supports the same protocol and technology as LAN 30. As described in more detail below with reference to FIGURES 2 through 5, access server 16 provides communication between the WAN supported by data network 18 and LAN 40.

In operation, device 12 using twisted pair subscriber lines 22 or LAN 30 generates information to indicate initiation of a session, and passes this information to communication server 20 and/or network interface 34. Data network 18 receives this information using link 50 and passes this information to access server 16 using link 52. Access server 16 then establishes a session and supports subsequent communication between devices 12 and 14.

FIGURE 2 illustrates in more detail access server 16. Links 52 of data network 18 couple to one or more WAN interfaces 100. Each WAN interface 100 couples to an associated first port 102 of switch fabric 104. A number of route processors (RP) 106 couple to second ports 108 of switch fabric 104. Route processors 106 also couple to LAN interface 110, which in turn couples to LANs 40 servicing devices 14. In a particular embodiment, WAN interface 100, switch fabric 104, route processors 106, and LAN interface 110 reside in a single housing, rack mount, or other arrangement of integrated or separate components at a single location in communication system 10.

A controller 112 manages the overall operation of access server 16. Controller 112 exchanges commands, operating statistics, and other information with components

of access server 16 using bus 114. A database 118 coupled to controller 112 stores program instructions 120, session table 122, and loading table 124. WAN interface 100, switch fabric 104, route processor 106, and LAN interface 110 access database 118 directly using bus 114 or indirectly using controller 112. Alternatively, information maintained in database 118 may reside in different components of access server 16 or in components external to access server 16. For example, switch fabric 104 may store one or more items maintained in session table 122 and/or loading table 124 locally.

Program instructions 120 include software code, parameters, and other instructions and data structures that controller 112 accesses and executes to control the operation of access server 16. Session table 122 maintains information regarding sessions handled by access server 16, and loading table 124 maintains information regarding the loading characteristics of route processors 106. Both session table 122 and loading table 124 are discussed in more detail with reference to FIGURES 3A and 3B.

Each route processor 106 maintains a routing table 130 and a client function 132. Routing table 130 maintains information that allows route processor 106 to route information between LAN 40 using LAN interface 110 and WAN 52 using WAN interface 100. Client function 132 collects and communicates information regarding the operation of route processor 106 to controller 112 using bus 114. In general, route processors 106 perform termination, conversion, segmentation, reassembly, addressing, and other functions supported by routers, bridges, gateways, multiplexers, and other WAN and LAN networking devices.

A server function 134 supported by controller 112 or an external server function accessed using link 136 uses information regarding the operation of route processor 106

5 to provide accounting and authentication services to access server 16. Both routing table 130 and client function 132 reside at route processor 106 as shown in FIGURE 2, in controller 112, database 118, other components of access server 16, and/or in remote components accessible by link 136.

10 WAN interface 100 and switch fabric 104 operate using the WAN protocol supported by data network 18, whereas LAN interface 110 operates using the LAN protocol supported by LAN 40. Route processors 106 provide termination of the WAN protocol, assembly, and/or conversion into a LAN protocol, authentication and error correction, and subsequent routing in the LAN protocol to device 14. These 15 operations performed by route processor 106 are processor-intensive and, in traditional routers, introduce a potential source of degradation in communication bandwidth.

20 To ameliorate or eliminate this degradation, switch fabric 104 balances the load on route processors 106 using loading characteristics that indicate the level of activity of route processors 106. This is performed by establishing sessions and, in one embodiment, assigning a virtual channel to each session. Switch fabric 104 then operates 25 in a high bandwidth WAN protocol and efficiently communicates information to selected route processors 106 based on the establishment of a session. As the session count increases and applications require greater bandwidth, access server 16 may upgrade or add route processors 106 to accommodate increased demands. Therefore, switch fabric 104 establishes sessions to balance the load on route 30 processors 106, which in turn ensures optimal and efficient provisioning of communication services by access server 16.

In operation, access server 16 receives a message indicating the initiation of a session on link 52 in a first protocol, for example, a WAN protocol such as ATM.

WAN interface 100 communicates the message to an associated port 102 of switch fabric 104. Switch fabric 104, either independently or with the assistance of controller 112, accesses loading table 124 in database 118. Switch fabric 5 104 then selects a route processor 106 based on its loading characteristics and/or the loading characteristics of the other route processors 106 in access server 16, as indicated in loading table 124. Switch fabric 104 then establishes a session and assigns an address (e.g., virtual 10 path, virtual channel) to be used in future communications associated with the session. Switch fabric 104 and/or controller 112 store session, address, and mapping information in session table 122. Access server 16 acknowledges establishment of a session by sending a 15 message using WAN interface 100 and link 52 to inform the originating device 12 of the establishment of a session and the address to be used in future communications. Before, after, or during the storage of information in session table 122 and the acknowledgment of the establishment of a 20 session, switch fabric 104 directs, couples, and/or switches the message to the selected route processor 106.

Switch fabric 104 directs subsequent communications from originating device 12 that include the address associated with the established session to the assigned 25 route processor 106. Route processor 106 then performs reassembly, conversion, authentication, error correction, and other suitable functions, and routes the message to destination device 14 using LAN interface 110 and LAN 40. During the operation of access server 16, client functions 30 132 collect and report loading characteristics of route processors 106 for storage in loading table 124. Also, route processors 106 modify or update information maintained in routing tables 130 based on information

received from LAN 40 concerning its operation, malfunction, or new network configuration.

During a session handled by access server 16, device 14 may communicate information to device 12. LAN interface 110 receives this information from LAN 40 and, based on information maintained in session table 122 or routing table 130, routes this information to route processor 106 associated with the session. Route processor 106 then performs segmentation, conversion, and other functions to prepare information for routing by switch fabric 104, WAN interface 100, and other components of communication system 10 to device 12.

Access server 16 establishes sessions originating from device 14 in a similar manner as sessions originating from device 12. LAN interface 110 receives a message from device 14 indicating the initiation of a session and selects route processor 106 based on loading characteristics maintained in loading table 124. Access server 16 assigns a session and associated address to be used in subsequent communications associated with the session. Controller 112 and/or LAN interface 110 store session, address, and mapping information in session table 122, and acknowledge the establishment of a session by sending a message to device 14 using LAN 40.

FIGURES 3A through 3C illustrate the contents of session table 122, loading table 124, and routing table 130 stored in database 118 of access server 16. Referring to FIGURE 3A, each entry in session table 122 includes a session ID 200, a route processor ID 202, an address 203, and mapping information 204. Session ID 200 is a unique or different designator assigned to each session currently handled by access server 16. Upon creation of a new session, access server 16 assigns a new session ID 200 and creates a new entry in session table 122. Upon the

expiration of a session (e.g., time-out, user termination, equipment malfunction) access server 16 removes the entry in session table 122 associated with the particular session ID 200.

5       Route processor ID 202 identifies route processor 106 selected for the particular session as a result of loading characteristics maintained in loading table 124. Address 203 represents the address used by access server 16 to identify communications associated with a session. In a 10 particular embodiment, address 203 may include a virtual path identifier (VPI), a virtual channel identifier (VCI), identifiers for ports 102 and 108 of switch fabric 104, or any other information that identifies a circuit, connection, coupling, or association made by switch fabric 15 104 for each session. One particular ATM implementation includes an eight bit VPI and a sixteen bit VCI, as illustrated by addresses 203 having two numbers separated by a period. Mapping information 204 represents information used by switch fabric 104 to perform its 20 switching function. For example, mapping information 203 may include ATM cell routing tables, identifiers for ports 102 and 108 of switch fabric 104, or other suitable mapping information.

Referring to FIGURE 3B, loading table 124 contains an 25 entry for each route processor 106 in access server 16. Each entry in loading table 124 includes a route processor ID 202, a packet rate 212, an error rate 214, a session count 216, and an idle time measure 218. Packet rate 212 may be expressed in thousands of messages per seconds 30 (kmps) and indicates the number of messages, packets, cells, or other grouping of information (referred to collectively as messages) handled by route processor 106 each second. Error rate 214 may also be expressed in thousands of messages per second (kmps) and indicates the

number of discarded, dropped, or corrupted messages received by route processor 106 each second. A high error rate 214 indicates a malfunction or high level of activity of route processor 106. Session count 216 tracks the 5 number of sessions currently handled by each route processor 106. In a particular embodiment, access server 16 includes up to ten route processors 106 that combine to service up to five thousand sessions, with a maximum of five hundred sessions for each route processor 106. Idle 10 time measure 218 may be expressed in milliseconds (ms) and indicates an idle time or other suitable measure that reflects the relative usage of route processor 106. Loading table 124 may include communication-based loading characteristics (e.g., packet rate 212, error rate 214, 15 session count 216), processor-based loading characteristics (e.g., idle time measure 218), or any other loading characteristics that indicate the level of activity, malfunction, and/or capacity of route processor 106.

Now referring to FIGURE 3C, routing table 130 20 maintains LAN routing information for each session handled by access server 16. Each entry includes a session ID 200, mapping information 222, an address 224, and routing information 226. As with session table 122, access server 16 adds and removes entries in routing table 130 as 25 sessions are established and terminated. Mapping information 222 includes a virtual path identifier (VPI), a virtual channel identifier (VCI), identifiers for ports associated with LAN interface 110, or any other information that enables LAN interface 110 to convey information 30 received from route processors 106 to LAN 40. In a particular embodiment, LAN interface 110 includes a switching capability that allows segmentation of LANs 40 for more efficient, modular, and fault tolerant communication. Mapping information 222 may also be used by

LAN interface 110 to direct information received from devices 14 serviced by LAN 40 to the selected route processor 106 assigned to the session.

Address 224 is a numerical or textual representation of an Internet protocol (IP/IPX) address, a network/node designation, or any other address used by LAN 40 to deliver information to device 14. Route processor 106 may convert address 224 for each session into an appropriate format, depending on the particular implementation of access server 16 and LAN 40. Routing information 226 includes routing information protocol (RIP) information, open-shortest-path-first (OSPF) information, or any other suitable routing information that provides the most efficient, available, or optimum path to communicate information to device 14 in LAN 40. Routing information 226 identifies particular nodes, paths, or other intermediate devices that establish a desirable route to device 14.

FIGURE 4 illustrates a flow chart of a method of operation of access server 16 in communication system 10. The method begins at step 400 where access server 16 receives a message at WAN interface 100 in a first protocol, such as a WAN protocol like ATM. WAN interface 100 communicates the message to an associated port 102 of switch fabric 104 at step 402. Switch fabric 104 then retrieves an address of the message at step 404. In the particular embodiment where WAN interface 100 and switch fabric 104 operate using ATM techniques, the address of the message comprises five bytes that specify, among other things, a virtual path identifier (VPI) and a virtual channel identifier (VCI).

Access server 16 determines whether a session associated with the retrieved address has already been established at step 406. This is performed by comparing the address of the message to addresses 203 maintained in

session table 122. In a particular embodiment, access server 16 sets aside particular addresses 203 representing default channels to receive requests to establish a new session. If the address of the message retrieved at step 404 does not match an address 203 maintained in session table 122, then access server 16 selects a route processor 106 based on loading characteristics maintained in loading table 124 at step 408. These loading characteristics may include packet rate 212, error rate 214, session count 216, 5 idle time measure 218, or any other loading characteristic of route processors 106. Access server 16 may consult loading characteristics of one or more route processors 106 in a random, sequential, or serial fashion to perform the 10 selection.

Access server 16 assigns the address of the message or other available address to the session at step 410 and stores information in session table 122 based on the selected route processor 106 and selected address 203 at step 412. Access server 16 then acknowledges establishment 15 of the session at step 414 by sending a message to device 12 that confirms establishment of a session, and informs device 12 of address 203 to be used in subsequent messages associated with the session.

If access server 16 already established the session as 20 determined at step 406, or after access server 16 establishes the session in steps 408-414, access server 16 communicates the message to the selected route processor 106 using information maintained in session table 122 at step 416. Route processor 106 terminates the message received in the first protocol at step 418. When using 25 ATM, route processor 106 terminates the ATM layer. Route processor 106 assembles the message into a packet or other form of information suitable for the application associated 30 with the session at step 420. Again using ATM techniques,

route processor 106 performs ATM adaptation layer (AAL) reassembly, for example, using AAL5. Route processor 106 then performs authentication and error correction of the packet at step 422.

5 Now in the second network protocol, such as a LAN protocol like Ethernet, route processor 106 communicates the packet to LAN interface 110 using information stored in routing table 130 at step 424. LAN interface 110 under the direction of information received from route processor 106, 10 selects the appropriate output port to LAN 40 and completes routing of the packet to the destination device 14 at step 426. Routing performed by LAN interface 110 may include or consider various conversions of address 224 as well as routing directives included in routing information 226. If 15 access server 16 receives more messages at step 428, then the process continues at step 400 to receive and process additional messages.

It should be understood that access server 16 may operate in a parallel and bidirectional fashion to receive 20 and process simultaneously messages from a number of different sources to be routed to a number of different destinations. Therefore, the process illustrated by FIGURE 5 represents the individual processing of a message, where in fact access server 16 processes thousands, millions, or 25 more of these messages each second.

FIGURE 5 illustrates the establishment of a session in communication system 10, and specifically the signaling performed by device 12, communication server 20, data network 18, access server 16, and device 14. Although data 30 network 18 is shown as a single messaging entity, communication system 10 contemplates a number of cascaded messaging entities as part of data network 18. For example, data network 18 represents multiple hops between

many ATM switching devices to deliver signals between communication server 20 and access server 16.

An application or other process running on device 12 requests a session by generating an initial session IP packet at 500. Device 12 communicates a setup message requesting a new call to communication server 20 at 502. Communication system 10 propagates the setup message from communication server 20 to data network 18 at 504, and from data network 18 to access server 16 at 506. During the propagation of the setup message, both communication server 20 and data network 18 issue a call proceeding message or other suitable acknowledgment at 508 and 510, respectively.

Upon receiving the setup message at 506, access server 16 performs steps 408-412 (FIGURE 4) to establish a session, and then communicates a session acknowledgment or connect message to data network 18 at 512. Communication system 10 propagates the connect message from data network 18 to communication server 20 at 514, and from communication server 20 to device 12 at 516. During this propagation, data network 18, communication server 20, and device 12 issue a connect acknowledge message at 518, 520, and 522, respectively. When device 12 receives the connect message at 516, communication system 10 verifies the establishment of a session and data transfer between device 12 and device 14 commences at 524.

Although the present invention has been described in several embodiments, a myriad of changes, variations, alterations, transformations, and modifications may be suggested to one skilled in the art, and it is intended that the present invention encompass such changes, variations, alterations, transformations, and modifications as fall within the spirit and scope of the appended claims.

WHAT IS CLAIMED IS:

1. A communication system, comprising:

a communication device;

5 a communication server coupled to the communication device using a subscriber line that forms a local loop between the communication device and the communication server; and

10 an access server coupled to the communication server using a data network, the access server comprising a switch fabric coupled to a plurality of route processors, wherein the switch fabric directs information from the communication device to a selected route processor based on its loading characteristics.

15 2. The communication system of Claim 1, further comprising a second communication device coupled to the access server and operable to receive information generated by the communication device from the selected route processor.

20 3. The communication system of Claim 1, wherein the selected route processor converts information received from the communication device from a wide area network protocol to a local area network protocol.

25 4. The communication system of Claim 1, wherein the selected route processor converts information received from the communication device from an asynchronous transfer mode protocol to an Ethernet protocol.

30 5. The communication system of Claim 1, wherein the selected route processor terminates information in a first network protocol and routes information in a second network protocol.

6. The communication system of Claim 1, wherein the communication device and the communication server communicate via the local loop using XDSL communication techniques.

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7. The communication system of Claim 1, wherein the loading characteristic for each route processor comprises a packet rate.

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8. The communication system of Claim 1, wherein the switch fabric establishes a virtual channel that indicates a coupling between the switch fabric and the selected route processor.

9. An access server, comprising:

a first network interface to receive information associated with a session;

5 a plurality of route processors, each route processor having a loading characteristic indicating its level of activity; and

10 a switch fabric having a first port and a plurality of second ports, the first port of the switch fabric coupled to the first network interface, each second port of the switch fabric coupled to an associated route processor, wherein the switch fabric couples information associated with the session to a selected route processor based on its loading characteristics.

15 10. The access server of Claim 9, wherein the loading characteristic for each route processor comprises a packet rate.

20 11. The access server of Claim 9, wherein the first network interface receives the information on a default channel associated with unassigned sessions.

25 12. The access server of Claim 9, wherein the switch fabric establishes a virtual channel that indicates the coupling between the switch fabric and the selected route processor.

13. The access server of Claim 9, wherein the selected route processor converts information associated with the session from a wide area network protocol to a local area network protocol.

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14. The access server of Claim 9, wherein the selected route processor converts information associated with the session from an asynchronous transfer mode protocol to an Ethernet protocol.

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15. The access server of Claim 9, wherein the first network interface, the route processors, and the switch fabric reside in a single housing.

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16. The access server of Claim 9, wherein the selected route processor terminates information associated with the session in a first network protocol and routes information associated with the session in a second network protocol.

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17. A method for communicating information associated with a session, comprising:

receiving a message indicating the initiation of a session;

5 determining loading characteristics on at least one of a plurality of route processors;

selecting a route processor for the session based on the loading characteristics; and

switching the message to the selected route processor

10 using a switch fabric.

18. The method of Claim 17, wherein the step of determining loading characteristics comprises determining a packet rate.

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19. The method of Claim 17, wherein the step of receiving comprises receiving the message on a default channel associated with unassigned sessions.

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20. The method of Claim 17, further comprising the step of converting the message from a first network protocol into a second network protocol at the selected route processor.

25

21. The method of Claim 20, wherein:

the first network protocol comprises asynchronous transfer mode; and

the second network protocol comprises Ethernet.

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22. The method of Claim 17, further comprising the following steps performed at the selected route processor:

terminating the message in a first network protocol; assembling the message into a packet in a second network protocol; and

35 routing the packet in a second network protocol.

23. The method of Claim 17, wherein the message comprises an address, and further comprising the step of switching a plurality of additional messages having the address to the selected route processor.

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24. The method of Claim 23, wherein the address identifies a virtual channel associated with the session.

10 25. The method of Claim 17, wherein the switch fabric comprises an asynchronous transfer mode switch fabric.

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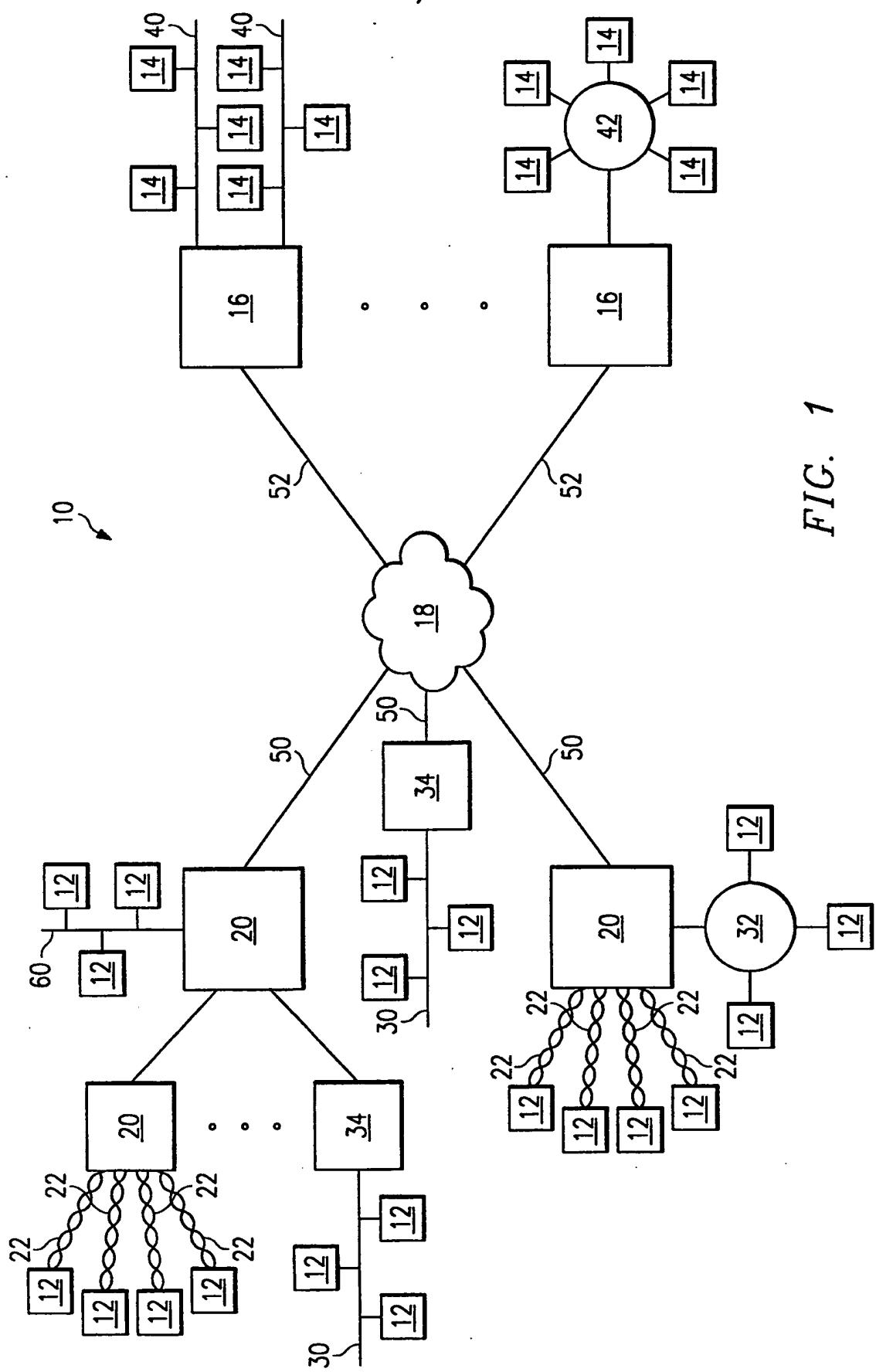


FIG. 1

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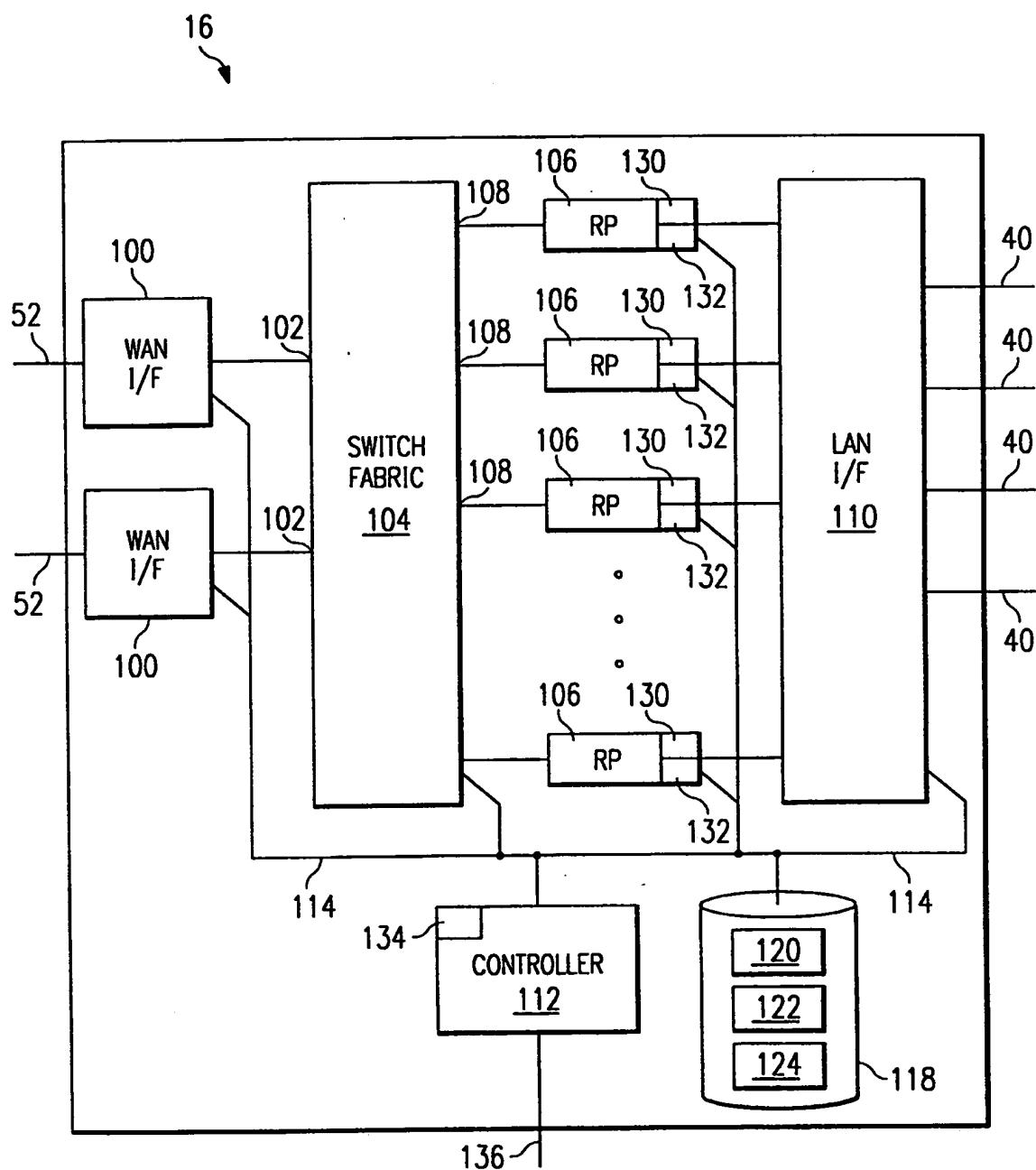


FIG. 2

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FIG. 3A

| SESSION ID | RP ID | ADDRESS   | MAPPING | 122 |
|------------|-------|-----------|---------|-----|
| 1          | 1     | 127.34967 | 1 → 1   |     |
| 2          | 2     | 36.19268  | 1 → 2   |     |
| 3          | 1     | 226.08962 | 2 → 1   |     |
| ⋮          | ⋮     | ⋮         | ⋮       |     |
| n          | 4     | 99.00001  | 2 → 4   |     |

FIG. 3B

| RP | PACKET RATE (kmps) | ERROR RATE (kmps) | SESSION COUNT | IDLE TIME MEASURE (ms) | 124 |
|----|--------------------|-------------------|---------------|------------------------|-----|
| 1  | 43                 | 0.4               | 41            | 1                      |     |
| 2  | 12                 | 0.1               | 8             | 2                      |     |
| 3  | 5                  | 0.0               | 2             | 8                      |     |
| 4  | 27                 | 0.2               | 23            | 3                      |     |

FIG. 3C

| SESSION ID | MAPPING | ADDRESS          | ROUTING  | 130 |
|------------|---------|------------------|----------|-----|
| 1          | 1 → 3   | 127.48.37.12     | —        |     |
| 2          | 2 → 1   | joe@net          | {NODE 1} |     |
| 3          | 1 → 4   | www.netspeed.com | —        |     |
| ⋮          | ⋮       | ⋮                | ⋮        |     |
| n          | 4 → 2   | betty.netspeed   | {NODE 3} |     |

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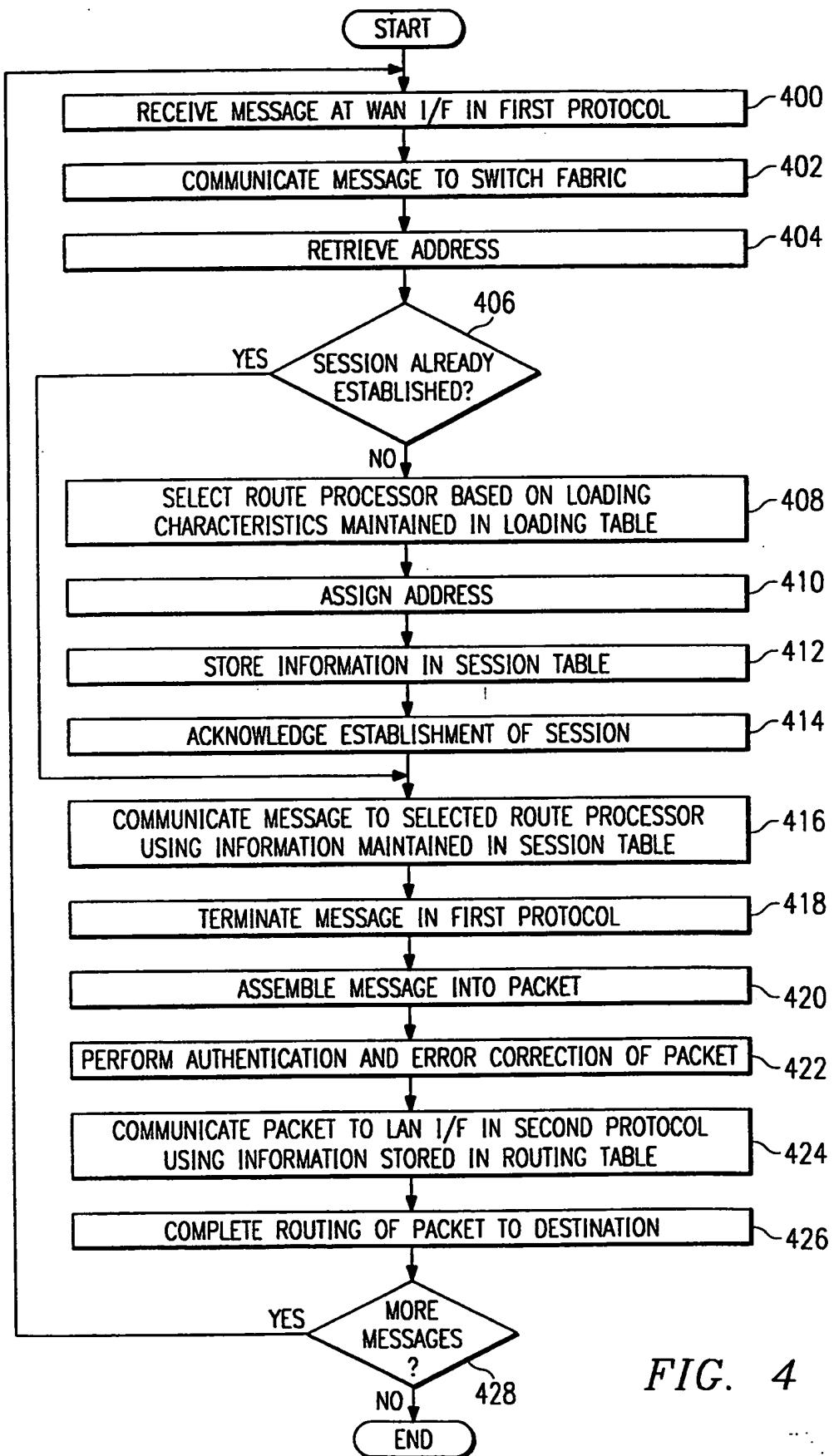
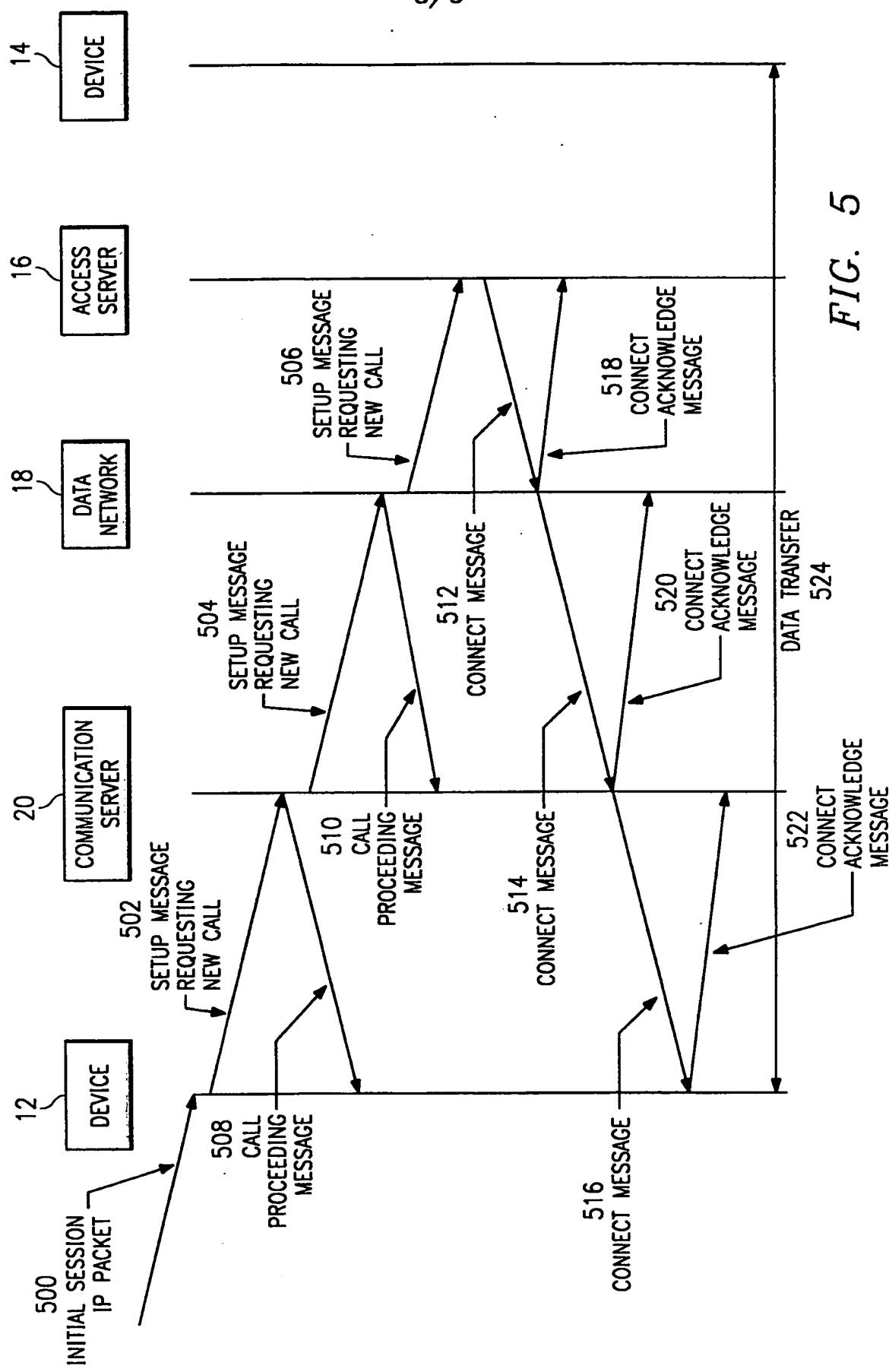


FIG. 4

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# INTERNATIONAL SEARCH REPORT

In. .tional Application No  
PCT/US 98/05822

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 H04Q11/04

According to International Patent Classification(IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No.           |
|----------|--|---------------------------------|
| Y        | WO 96 04729 A (3COM CORP) 15 February 1996<br><br>see page 2, line 1 - line 9<br>see page 5, line 19 - line 27<br>see page 4, line 11 - line 19<br>--- | 1-5, 7, 8,<br>13, 14,<br>20, 21 |
| X        | EP 0 677 941 A (FUJITSU LTD) 18 October<br>1995  | 9, 10, 17,<br>18, 25            |
| Y        | see column 2, line 18 - line 41<br>---   | 1-5, 7, 8,<br>13, 14,<br>20, 21 |
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

29 June 1998

Date of mailing of the international search report

09/07/1998

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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 98/05822

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
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| A        | US 5 668 857 A (MCHALE JOHN F) 16<br>September 1997<br>cited in the application<br>* abstract *<br>-----  | 6                     |

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

Int'l Application No

PCT/US 98/05822

| Patent document cited in search report | Publication date | Patent family member(s) |  | Publication date |
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